

IEEE INTERNATIONAL CONFERENCE ON HIGH PERFORMANCE SWITCHING AND ROUTING (IEEE HPSR 2023)

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IEEE International Conference on High Performance Switching and Routing 2023 was organized in Albuquerque, NM, USA, June 5–7, 2023, and was the 24th edition of the conference. More than 47 participants attended the conference in person and several more participants joined remotely. The Organizing Committee consisted of Dr. Dimitrios Koutsonikolas, Dr. Carla Fabiana Chiasserini, and Dr. Gang Li, TPC Co-Chairs, Dr. Anna Maria Vegni and Dr. Aris Leivadreas, Workshop Co-Chairs, Dr. Chiara Boldrini, Tutorial Chair, Dr. Xiang Sun, Posters and Demos Chair, Dr. Pantelis Frangoudis, and Dr. Andrea Morichetta, Publication Co-chairs, Dr. Suzan Bayhan, Dr. Sumitro Bhaumik, and Dr. Zhu Wang, Publicity Co-chairs, Dr. Symeon Papavassiliou, Panel Chair, and the website was handled by Md Sadman Siraj, and Panagiotis Charatsaris, Web Co-chairs. IEEE continuously supported the conference with Shirley P. Cisneros, ComSoc Project Manager, and Bruce Worthman, Financial Chair.

The 24th edition of the IEEE International Conference on High Performance Switching and Routing focused on the topic of *Artificial Intelligent Next Generation (NextG) Integrated Communications and Computing Systems* by bringing together experts from industry, academia, and research labs to exchange their vision as well as their achieved advances in the continuing evolution of high performance switching and routing. 42 technical papers were submitted in the main conference and 18 papers were accepted to be presented in five technical sessions, organized in the following topics: Programmable Control and Data Plane, Switching and Routing, Wireless Networks, Machine Learning & Networks, and Terrestrial and Aerial Mobile Networks. All of the papers underwent a rigorous review process with at least three reviews per paper.

Two tutorials were presented on the first day of the conference, following the welcome message from Dr. Eirini Eleni Tsiropoulou, General Chair. The two tutorials focused on next-generation networking and computing technologies:

1. An Overview of a Distributed Post-5G Network Architecture within the EU SLICES-RI Research Infrastructure, Prof. Raymond Knopp, Prof. Adlen Ksentini, Dr. Damien Saucez, and Dr. Nikos Makris.
2. Introduction to Networking Technologies for High-Performance Computing, Prof. Dhabaleswar K. (DK) Panda and Prof. Hari Subramoni.

Also, during the first day of the conference, an online workshop was organized in parallel to the main conference focusing on a wide variety of topics related to high performance switching and routing. The online session was moderated by Dr. Anna Maria Vegni and Dr. Aris Leivadreas, Workshop Co-Chairs.

In the evening of the first day, the posters and demos were presented attracting the interest of the participants and engaging them in fruitful discussions in the field of *Artificial Intelligent Next Generation (NextG) Integrated Communications and Computing Systems*.

The opening remarks of IEEE HPSR 2023 were delivered on the second day of the conference by Dr. Dimitrios Koutsonikolas, TPC Co-Chair. The first keynote talk, "Latency is the new Bandwidth," was delivered in the morning on the second day of the conference by Dr. Shivendra S. Panwar. Dr. Panwar's keynote focused on the evolution of wireless networks in 5G systems, which can deliver tens of megabits per second to

users, and will soon provide more, becoming comparable to the data rates achieved by the wireline networks. It was highlighted that for most applications, including mobile applications, bandwidth availability is no longer viewed as a serious constraint. The next driver of advances in networking was highlighted to be the need for reliable low latency connectivity, rather than bandwidth alone. These applications include XR (Augmented Reality, Virtual Reality and Mixed Reality), wirelessly controlled robots, and haptic communications. The latency requirements for such applications will vary from tens of milliseconds down to the sub-millisecond range. During the keynote talk, it was highlighted that the latency requirements for these applications can be met by carefully engineered wired and wireless communications, typically in controlled indoor environments, but it remains an open challenge to provide them over cellular networks. Overall, the talk analyzed the emerging challenge of providing reliable low latency broadband communications over cellular networks.

The second day of the conference was followed by three technical sessions in the fields of Programmable Control and Data Plane, Switching and Routing, and Wireless Networks. The presentation of the best paper was delivered by Ufuk Usubutun from New York University & Tandon School of Engineering, USA answering the question, "Do Switches Still Need to Deliver Packets in Sequence?" The presentation focused on the problem of Internet switches, which become harder and costlier to build for higher line rates and switch capacities. The presenter analyzed that in-sequence delivery of packets has traditionally been a constraint on switch designs because TCP loss detection was considered vulnerable to out-of-sequence arrivals. For this reason, extremely efficient and simple designs, such as the Load Balanced Birkhoff-von Neumann Switch, were considered impractical. The author presented a reevaluation of this constraint considering modern TCP implementations with loss detection algorithms, like Recent Acknowledgment (RACK), that are more resilient to out-of-order arrivals. A detailed set of testbed experiments representative of wide area core networks were presented to evaluate the performance of TCP flows traversing a load balanced switch that reorders some packets within a flow. The presenter showed that widely deployed and standard TCP implementations of the last decade achieve similar performance when traversing a load balanced switch as they do when there is no reordering. Also, representative results were demonstrated to verify that an increase in the line rate leads to favorable conditions for time-based loss detection methods, such as the one used in RACK. The presenter concluded that switch designs that were previously thought to be unsuitable can potentially be utilized, thanks to the relaxation of the in-sequence delivery constraint.

The paper titled, "A Multi-Table Programmable Parser for Satellite Networks," co-authored by Jin Zhang, Daoye Wang, Kai Liu, and Jianhua Lu (Tsinghua University, China), attracted the interest of the participants by proposing a Multi-Table Programmable Parser (MTPP), consisting of five tables and corresponding protocol independent fixed logic to represent a parser graph. Based on MTPP, the authors explained in their presentation that the online configuration is achieved by changing table entries at runtime. The authors demonstrated a detailed numerical analysis

under typical parse graphs showing that MTPP uses less storage resources than that in a PISA-based parser. Also, the paper entitled, “D3T: Double Deep Q-Network Decision Transformer for Service Function Chain Placement,” co-authored by Binghui Wu, Dongbo Chen, Venkata Abhishek Nalam, and Mohan Gurusamy (National University of Singapore and Singapore Institute of Technology) attracted the interest of the audience by proposing an effective algorithm Double Deep Q-Network Decision Transformer (D3T) to optimize the Service Function Chain placement. Other interesting topics discussed were the development of greener data centers via programmable data plane, the network traffic prediction with attention-based spatial-temporal graph network, reinforcement learning-based congestion control for real-time applications, and many more.

At the end of the second day of the conference, a two-and-a-half hour tutorial was presented on the topic of Network Softwarization at the Edge With SD-WAN, delivered by Prof. Sebastian Troia and Prof. Guido Maier. The tutorial was very well-attended and vibrant discussions took place during the presentation, as well as at the end of the session. The tutorial addressed the Software-Defined Wide Area Network (SD-WAN) technology, which has recently conquered the enterprise-networking market all over the world. SD-WAN is regarded as very promising for the next-generation WANs, especially by the Communication Service Providers (CSPs), as a new highly effective solution they can offer to their customers. SD-WAN brings the advantages of SDN to the WAN, applying the concept of separation among data and control plane. The main goal is to provide dynamic, fast, and reliable interconnections between the sites of an organization, such as headquarters, datacenters, branch offices, that are geographically distributed over a wide area. A communication infrastructure with a national, international, or even global extension can thus be provided to the tenants as an overlay network over heterogeneous public WANs. SD-WAN reduces the costs but has to preserve the same quality of service of alternative, more expensive technologies, such as MPLS. The tutorial’s presenters introduced a detailed overview of SD-WAN by addressing the most important use cases, such as enterprise branch-to-headquarter and headquarter-to-datacenter switching interconnection. They focused on the network architecture requirements in order to obtain an agile and efficient control plane. Also, they described the decision techniques that can be implemented inside the SD-WAN controller, making a comparison between traditional and machine-learning solutions. During the tutorial, the presenters displayed some testbeds and presented a live demo.

In the evening of the second day, the best paper award was presented. The best paper award was assigned based on the weighted score of the reviews, the overall paper quality, and the received comments by all the reviewers. The paper, “Do Switches Still Need to Deliver Packets in Sequence?” co-authored by Ufuk Usubutun, Fraida Fund, Shivendra Panwar, New York University & Tandon School of Engineering, USA, received the best paper award.

The third day of the conference started with a keynote talk presented by Dr. Ian F. Akyildiz on the topic, “A New CubeSat Design with Reconfigurable Multi-band Radios for Dynamic Spectrum Access in Internet of Space Things.” Dr. Akyildiz started his talk focusing on small satellites, or CubeSats, which are envisioned as a promising solution for future satellite communication networks because of their low costs and short deployment cycle. Dr. Akyildiz described that CubeSats communicate at conventionally allocated satellite communication frequencies. However, with the increase in the number of CubeSats, CubeSat-enabled communication systems, and many new use cases, new spectrum bands and more efficient spectrum usage are needed. Dr. Akyildiz presented a novel CubeSat design with



FIGURE 1. Dr. Eirini Eleni Tsiropoulou, General Chair, welcoming the IEEE HPSR 2023 participants.



FIGURE 2. Dr. Dimitrios Koutsonikolas, TPC Co-chair, presenting the opening remarks.



FIGURE 3. “Latency is the new Bandwidth,” keynote talk delivered by Dr. Shivendra S. Panwar.



FIGURE 4. Best paper award of IEEE HPSR 2023 for the paper, “Do Switches Still Need to Deliver Packets in Sequence?” co-authored by Ufuk Usubutun, Fraida Fund, Shivendra Panwar, New York University & Tandon School of Engineering, USA.

reconfigurable multi-band radios for communication in dynamic frequencies is proposed. Specifically, the multi-band radio design is realized by two complementary approaches, namely, an electronics-based and a photonics-based approach. The multi-band communication covers a wide range from radio frequencies (2–30 GHz), millimeter wave (30–300 GHz), Terahertz band (up to 10 THz), and optical frequencies (with typical bands of 850 nm/350 THz, 1300 nm/230 THz, and 1550 nm/193 THz). Dr. Akyildiz presented a thorough link budget analysis to demonstrate the potential of the proposed multi-band architecture for space information networks. Also, he analyzed the key parameters in the satellite constellation design to explore the feasibility of deployment at different altitudes in the exosphere orbit (500 km and above). Furthermore, Dr. Akyildiz discussed the software-defined networking (SDN), and network function virtualization (NFV), which have been incorporated to effectively separate the abstraction of functionalities from the hardware by decoupling the data forwarding plane from the control plane, where this separation is of prime importance given the limited onboard processing on CubeSats. Finally, Dr. Akyildiz analyzed key parameters in the constellation design, including the coverage footprint, number of CubeSats, orbital planes, etc., which

are investigated for feasibility and deployment studies at different altitudes in the exosphere orbit.

The third day of the conference continued with two more technical sessions on the fields of Machine Learning & Networks, and Terrestrial and Aerial Mobile Networks. Also, at the end of the third day, there were two other two-and-a-half hour tutorials presented:

1. The Role of Data Engineering In Network Automation, Dr. Engin Zeydan and Dr. Josep Mangués-Bafalluy.
2. 6G Network Slicing Technics: Recent Advances, Standards, and Challenges, Prof. Jiadai Wang and Prof. Jiajia Liu.

The Organizing Committee received very encouraging comments from the participants regarding the technical program of the conference, as well as of its excellent organization. The Organizing Committee would like to thank all the Technical Program Committee members, the authors, the keynote speakers, and all of the participants for making IEEE HPSR 2023 a remarkable experience, as well as the volunteers that supported the local arrangements during the three-day conference: *Aisha B. Rahman, Md Sadman Siraj, Arianna Santamaria, Jenilee Jao, and Adedamola Adesokan*. Extended versions of selected papers will be fast-tracked to: Computer Networks (Impact factor 5.493).